

TM-11-5109

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Hold for Allen

**INSTRUCTION BOOK
FOR
SLOTTED LINE,
NARDA MODEL 230**

**PREPARED FOR
THE SIGNAL CORPS ON
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FORWARD COMMENTS ON THIS PUBLICATION DIRECTLY TO:

Commanding Officer

The Signal Corps Publications Agency

Fort Monmouth, New Jersey

ATTN: Standards Division

WARNING

DANGEROUS VOLTAGES ARE ENCOUNTERED WHEN USING THIS EQUIPMENT

Avoid contact with klystron and power supply terminals when using this equipment with bench oscillators. Avoid contact with rf voltages on transmission lines and antennas when using this equipment with radar systems.

DON'T TAKE CHANCES!

SLOTTED LINE, NARDA MODEL 230

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Note. This instruction book will be replaced by TM 11-5109 which, when published, will be listed in Department of the Army Pamphlet No. 310-4.

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

This manual contains instructions for the installation, operation, maintenance, and repair of Slotted Line, NARDA Model 230 (fig. 1).

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army materiel and equipment.

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745-45-5 (Army); Navy Shipping Guide, Article 1850-4; and AFR 71-4 (Air Force).

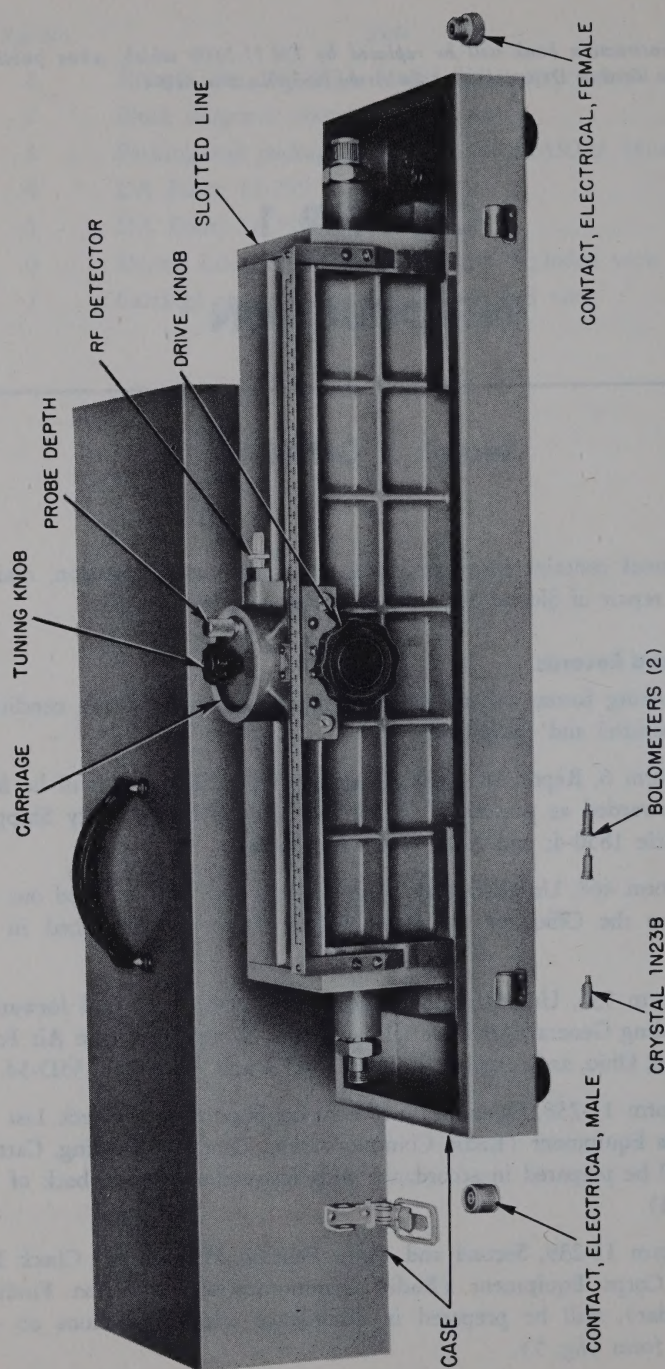
b. DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700-45-5.

c. DD Form 535, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700-45-5 and AF TO 00-35D-54.

d. DA Form 11-238, Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 4).

e. DA Form 11-239, Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 5).

f. Use other forms and records as authorized.



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Figure 1. Slotted Line, NARDA Model 230, components.

Section II. DESCRIPTION AND DATA

3. Purpose and Use

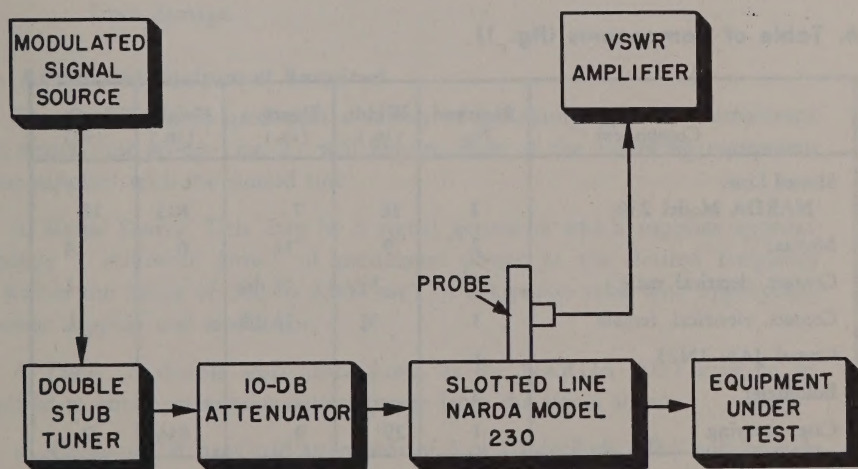
a. Slotted Line, NARDA Model 230 (fig. 1) is a general purpose portable slotted line or impedance meter. It is used to measure voltage standing wave ratios (vswr) and impedances in the frequency range of 500 to 4,000 megacycles (mc) per second.

b. Slotted Line, NARDA Model 230 is specifically intended for measuring the vswr of coaxial components equipped with type N connectors (male or female).

c. The Slotted Line, NARDA Model 230 consists of a section of coaxial transmission line of the parallel plane type, a pick-up probe, and a radio frequency detector which uses a 1N23 crystal or a bolometer (NARDA N-610B).

d. Normally, the Slotted Line, NARDA Model 230 is used in conjunction with a modulated signal source and a vswr amplifier, such as Standing Wave Indicator TS-12/AP, as shown in block diagram form in figure 2.

e. In this manual, Slotted Line, NARDA Model 230 will be called the slotted line.



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Figure 2. Block diagram showing bench set-up.

4. Technical Characteristics

Frequency range.....	500 to 4,000 mc.
Nominal impedance.....	50 ohms.
Residual vswr.....	1.04.
Detecting element.....	1N23 crystal or a bolometer.
Calibration.....	Calibrated in millimeters with vernier.
Connectors.....	Male and female, type N. One end mates with Radio Frequency Jack UG-23/U; other end mates with Radio Frequency Plug UG-21/U. Output of detector is BNC female to mate with Plug UG-260/U.
Weight.....	27.6 lb.

5. Packaging Data

a. The slotted line is housed in a 29 by 9 by 8½-inch metal carrying case. Two bolometers in plastic vials are mounted in spring clips in the bottom of the case, and the crystal is stored in the slotted line radio frequency detector. Male and female shorting sections are mounted on the ends of the carriage.

b. When packaged for export shipment, the case containing the slotted line, plus a desiccant, is inclosed in moisture-vaporproof barriers and packed in fiberboard containers. See figure 3.

c. When packaged for domestic shipment, the case containing the slotted line is inclosed in a cushioned fiberboard container.

Note. Items may be packaged in a manner different from that shown, depending on supply channels.

6. Table of Components (fig. 1)

Component	Required No.	Width (in.)	Depth (in.)	Height (in.)	Weight (lb)
Slotted Line, NARDA Model 230	1	26	7	8¼	18
Manual	2	9	¼	6	.4
Contact, electrical, male	1	¾	¾ dia		.1
Contact, electrical, female	1	¾	⅞ dia		.1
Crystal JAN 1N23	1				
Bolometer	2				
Case, carrying	1	29	9	8½	9
Total					27.6

Note. This list is for general information only. See appropriate supply publications for information pertaining to requisition of spare parts.

7. Description of Components

a. Slotted Line, NARDA Model 230. The slotted line consists of a central section of transmission line and coaxial input and output connectors and adapters. The central section of transmission line consists of two parallel plates with a center conductor and a movable carriage. The carriage contains the probe, tuning mechanism, and detector, and slides on this central portion of the line. The slotted line is equipped with four rubber feet and is cradled in its case in rubber shock mounts. The cover of the case is completely detachable, so that the slotted line may be left in the base or removed and operated directly on the bench. The supplied crystal is located in the radio frequency detector, and the two bolometers in plastic vials are mounted in spring clips located at the bottom of the case.

b. Accessories. The following accessories are supplied with the slotted line.

- (1) *Crystal, JAN 1N23B.* This standard silicon-type crystal diode is used for detection.
- (2) *Bolometer.* The two bolometers are of the Wollaston wire type, mechanically interchangeable with 1N21 and 1N23 crystals. The nominal resistance is 200 ohms at 8.75 milliamperes (ma).
- (3) *Male Electrical Contact.* This is a reference short circuit for connection to any type N female connector. It is mounted on the female connector of the slotted line and it serves to protect the connector from damage.
- (4) *Female Electrical Contact.* This is a reference short circuit for connection to any type N male connector. It is mounted on the male connector of the slotted line and it serves to protect the connector from damage.

8. Additional Equipment Required

The slotted line is used with a variety of laboratory-type test instruments. A typical test set-up (fig. 2) will require most of the following equipment *not* supplied with the slotted line.

a. Signal Source. This may be a signal generator which supplies approximately 1 milliwatt (mw) of modulated power at the desired frequency (within the limits of 500 to 4,000 mc) or a klystron tube with appropriate power supplies and modulator.

b. Tuner. A double stub tuner (such as the NARDA 903) may be required to obtain maximum output power from the signal source.

c. Attenuator. A fixed-pad attenuator of 5 or 10 decibels (db) will provide adequate isolation.

d. Vswr Amplifier. The output of the slotted line detector should be fed to a vswr amplifier such as Standing Wave Indicator TS-12/AP.

CHAPTER 2

OPERATION

Note. This chapter locates, illustrates, and furnishes the operator with sufficient information pertaining to the various controls and instruments provided for the proper operation of the equipment.

Section I. SERVICE UPON RECEIPT OF SLOTTED LINE, NARDA MODEL 230

9. Placement of Equipment

Place the slotted line on a firm support such as a laboratory- or shop-type bench. Place it so that it will be easy to make direct connection to the equipment under test and to the auxiliary equipment required. Usually the vswr amplifier is placed behind the slotted line. The controls on the slotted line and the vswr amplifier should be within convenient reach of the operator.

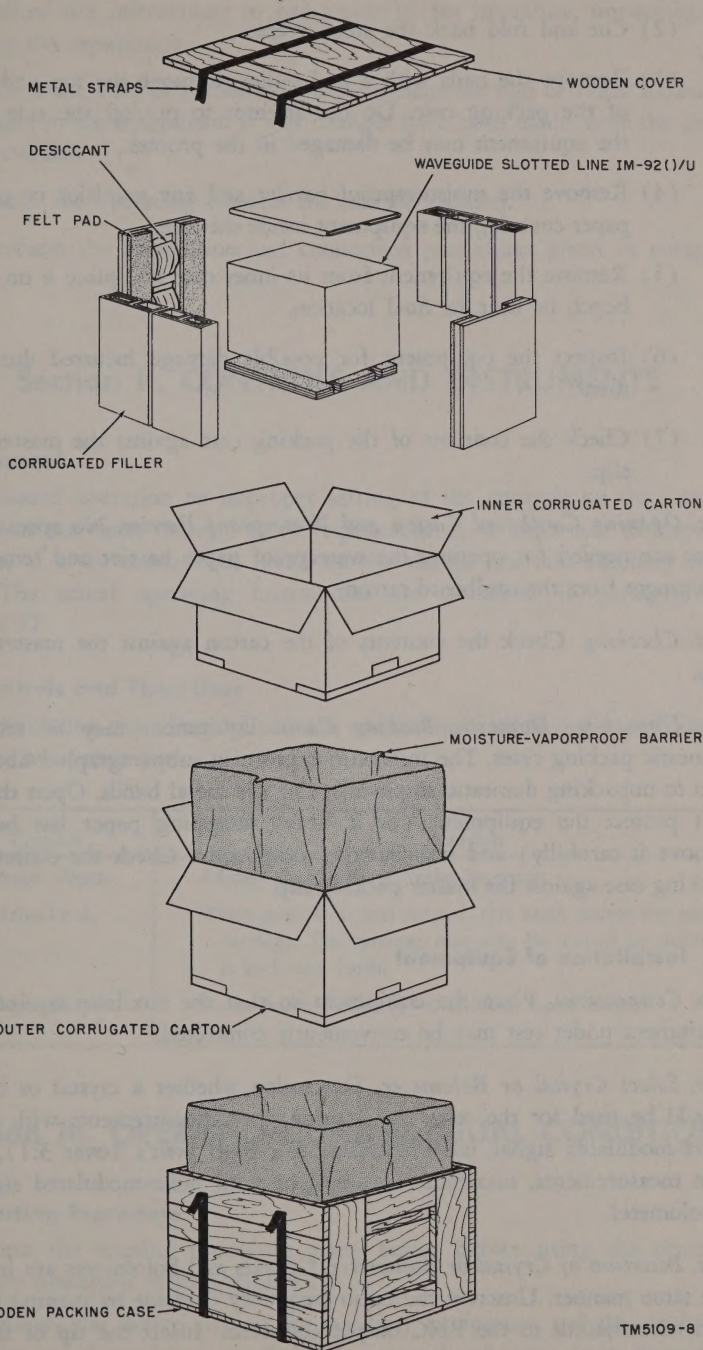
10. Uncrating, Unpacking, and Checking New Equipment

Note. For used or reconditioned equipment, refer to paragraph 12.

a. General. Equipment may be shipped in oversea packing cases or in domestic packing cases and, sometimes, in its own carrying case. When new equipment is received, select a location where the equipment may be unpacked without exposure to the elements and which is convenient to the permanent or semipermanent installation of the equipment. The instructions in subparagraph *b* below apply to equipment shipped in export packing cases, and the instructions in subparagraph *e* below, to equipment in domestic packing cases. When equipment is shipped in carrying cases, no special unpacking and uncrating procedures are necessary aside from checking to make sure that all carrying cases are present and that the equipment is undamaged.

Caution: Be careful when uncrating, unpacking, and handling the equipment; it is easily damaged. If it becomes damaged or exposed, a complete overhaul may be required or the equipment may be rendered useless.

b. Step-by-step Instructions for Uncrating and Unpacking Export Shipments (fig. 3).



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Figure 3. Packing and packaging Slotted Line, NARDA Model 230.

- (1) Place the packing case as near the operating position as convenient.
- (2) Cut and fold back the steel straps.
- (3) Remove the nails with a nail puller. Remove the top and one side of the packing case. Do not attempt to pry off the side and top; the equipment may be damaged in the process.
- (4) Remove the moistureproof barrier and any excelsior or corrugated paper covering the equipment inside the case.
- (5) Remove the equipment from its inner case and place it on the work bench or near its final location.
- (6) Inspect the equipment for possible damage incurred during shipment.
- (7) Check the contents of the packing case against the master packing slip.

c. Opening Cardboard Carton and Waterproof Barrier. No special instructions are needed for opening the waterproof paper barrier and removing the equipment from the cardboard carton.

d. Checking. Check the contents of the carton against the master packing slip.

e. Unpacking Domestic Packing Cases. Equipment may be received in domestic packing cases. The instructions given in subparagraph *b* above apply also to unpacking domestic shipments. Cut the metal bands. Open the cartons that protect the equipment (or if heavy wrapping paper has been used, remove it carefully) and take out the components. Check the contents of the packing case against the master packing slip.

11. Installation of Equipment

a. Connections. Place the equipment so that the auxiliary equipment and equipment under test may be conveniently connected.

b. Select Crystal or Bolometer. Determine whether a crystal or bolometer should be used for the tests. For routine vswr measurements with a square-wave-modulated signal, use the crystal. For high vswr's (over 3:1), attenuation measurements, maximum accuracy, or with pulse-modulated signals, use a bolometer.

c. Insertion of Crystal or Bolometer. Crystals and bolometers are inserted in the same manner. Unscrew the radio frequency detector by turning the hexagon nut adjacent to the BNC output connector. Insert the tip of the crystal or bolometer in the small hole in the detector assembly and screw the assembly back in place.

12. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 10 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for tags or other indications of changes in the equipment. If any changes have been made, note the change in this manual.

c. Check the operating controls for ease of rotation.

d. Perform the installation and connection procedures given in paragraph 11.

Section II. CONTROLS AND INSTRUMENTS

13. General

Haphazard operation or improper setting of the controls on the auxiliary equipment can cause damage to the equipment. It is important to know the function of every control and meter on the slotted line and auxiliary equipment. The actual operating instructions are contained in paragraphs 15 through 17.

14. Controls and Their Uses

The following chart lists the controls and instruments of the slotted line and indicates what they do:

Control	Function
Probe depth	Adjusts the depth of probe insertion.
Drive knob	When pushed in and rotated, this knob moves the probe carriage. The carriage may also be moved by pushing it back and forth.
Tuning knob	Tunes probe output for maximum signal output.

Section III. OPERATION UNDER USUAL CONDITIONS

15. Starting Procedure

Perform the starting procedure given below before using the operating procedure described in paragraph 16.

a. Connect the slotted line to the auxiliary equipment and the equipment under test as indicated in figure 2. Insert a crystal or bolometer in the detector as indicated in paragraph 11*c.*

Caution: The following precautions are to be observed when using a bolometer: The CRYSTAL-BOLOMETER switch on the vswr amplifier must be in the CRYSTAL position when inserting the bolometer and while connecting or disconnecting either end of the cable connecting the detector output to the vswr amplifier. Make sure that the vswr amplifier is wired to supply approximately 8.75 ma bias current to a 200-ohm bolometer. If the amplifier has a bias current control adjust it for 8.75 ma. After the cable is connected, switch the CRYSTAL-BOLOMETER switch to the BOLOMETER position.

b. Set the probe depth to maximum by turning the small knurled knob on top of the carriage fully clockwise.

c. Adjust the tuning knob for a setting that gives maximum indication on the output meter of the vswr amplifier. Decrease the gain of the amplifier, if necessary, to keep the meter deflection on scale.

d. Decrease the probe depth by turning the small knurled knob on top of the carriage counterclockwise, and increase the gain of the amplifier. Use the minimum probe depth that will give a full scale deflection on the vswr amplifier which is set to nearly full gain. If signal level is low, probe depth may have to be increased to obtain a usable meter deflection free of noise or jitter.

16. Operating Procedure

a. Vswr Measurements.

- (1) Move the probe carriage along the length of the slotted line, by sliding the carriage by hand or by pushing in the drive knob and turning it to drive the carriage. Set the carriage to the position which gives a maximum meter reading on the vswr amplifier.
- (2) Adjust the gain of the vswr amplifier so that the meter reads *exactly* full scale (1 on the VSWR scale, 0 on the db scale).
- (3) Move the carriage to obtain a minimum meter reading.
- (4) The meter reading at this setting is the vswr of the equipment under test at the signal frequency.

b. Impedance Measurements.

- (1) Measure the vswr as explained in subparagraph a above.
- (2) Move the carriage to the end of the slotted line that is nearest the equipment under test. Move the carriage back until the reading on the vswr amplifier meter is at a minimum.
- (3) Record the carriage position in centimeters, using the scale and vernier.
- (4) Disconnect the equipment under test, and connect in its place the electrical contact short circuit supplied with the equipment.

- (5) Repeat the steps in subparagraphs (2) and (3) above.
- (6) Determine the wave length in centimeters and add one-half of that value to the reading obtained in subparagraph (5) above. (Refer to subparagraph (10) below if the wave length is unknown.)
- (7) Subtract the reading obtained in subparagraph (3) from the value obtained in subparagraph (6). The difference is the actual distance between the *minimum* for the equipment under test and its junction with the slotted line.
- (8) Plot the vswr and *minimum distance* on a Smith chart following the instructions supplied with the chart to determine the normalized impedance.
- (9) Multiply the normalized impedance by the characteristic impedance (50 ohms) of the slotted line. The result equals the impedance of the equipment under test.
- (10) If the wave length is unknown, measure the distance on the scale between two adjacent minimums. The distance measured is equal to one-half the wave length.

17. Stopping Procedure

- a. Move the CRYSTAL-BOLOMETER switch on the vswr amplifier to the CRYSTAL position.
- b. Disconnect all cables and auxiliary equipment.
- c. Replace the electrical shorting contacts (male and female) on the two end connectors of the slotted line.
- d. Replace the slotted line and accessories in the carrying case and secure all four latches.

Section IV. OPERATION UNDER UNUSUAL CONDITIONS

18. General

The operation of Slotted Line, NARDA Model 230 may be difficult in regions where extreme cold, heat, humidity and moisture, sand conditions, etc., prevail. Every precaution is taken in the design of the equipment to maintain its technical characteristics over wide temperature and humidity ranges. Adverse conditions may cause operating difficulties, but no errors in measurements will result.

19. Operation in Arctic Climates

Subzero temperatures may result in frost accumulation and consequent locking or jamming of the controls and other moving parts. Observe the following precautions.

a. Keep the equipment warm and dry and under protective cover when not in use.

b. When equipment that has been exposed to the cold is brought into a warm room it will probably *sweat*. When the equipment has reached room temperature, dry it thoroughly.

20. Operation in Tropical Climates

When operated in tropical climates, test equipment may be installed in tents, huts, or, when necessary, in underground dugouts. When equipment is installed below ground and when it is set up in swampy areas, moisture conditions are more acute than normal. Ventilation is usually very poor, and the high relative humidity causes condensation of moisture on the equipment whenever the temperature of the equipment becomes lower than that of the surrounding air.

21. Operation in Desert Climates

a. The main problem that arises with equipment operation in desert areas is the large amount of sand, dust, or dirt that enters the moving parts of test equipment. The ideal preventive precaution is to house the equipment in a dustproof shelter. Since such a building is seldom available and would require air conditioning, the next best precaution is to make the building in which the equipment is located as dustproof as possible with available materials. Hang wet sacking over the windows and doors, cover the inside walls with heavy paper, and secure the side walls of tents with sand to keep them from flapping in the wind.

b. Keep the equipment as free from dust as possible. Make frequent preventive maintenance checks (par. 24 through 27).

c. A drastic fall in temperature at night often causes condensation. To prevent this, cover the equipment with tarpaulin or a similar covering material.

CHAPTER 3

ORGANIZATIONAL MAINTENANCE

Section I. ORGANIZATIONAL TOOLS AND EQUIPMENT

22. General

a. Usually a number of tools, materials, or tool equipment kits are either furnished with the equipment or supplied to the organization for use with the equipment.

b. The actual allowable organizational maintenance that can be performed on Slotted Line, NARDA Model 230 depends to a large extent on the existing military regulations (standing operating procedure), the existing tactical situation, and also on the tools and other test equipment issued.

23. Tools and Materials

Tools and materials used, but not supplied, with Slotted Line, NARDA Model 230 consist of one Tool Equipment TE-113, carbon tetrachloride, and Solvent, Dry Cleaning (SD) (Federal P-S-661a).

Section II. PREVENTIVE MAINTENANCE SERVICES

24. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from trouble shooting and repair since its object is to prevent certain troubles from occurring.

25. General Preventive Maintenance Techniques

- a.* Use #0000 sandpaper to remove corrosion.
- b.* Use a clean, dry, lint-free cloth for cleaning.
 - (1) If necessary, except for electrical contacts, moisten the cloth with solvent (SD); after cleaning, wipe the parts dry with a dry cloth.
 - (2) Clean electrical contacts with a cloth moistened with carbon tetrachloride; then wipe them dry with a dry cloth.

Caution: Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Make sure adequate ventilation is provided.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from inaccessible places; be careful, however, or mechanical damage from the air blast may result.

d. For further information on preventive maintenance techniques, refer to TB SIG 178, Preventive Maintenance Guide for Radio Communication Equipment.

26. Use of Preventive Maintenance Forms

(fig. 4 and 5)

a. The decision as to which items on DA Forms 11-238 and 11-239 are applicable to this equipment is a tactical decision to be made in the case of first echelon maintenance by the communication officer/chief or his designated representative, and, in the case of second and third echelon maintenance, by the individual making the inspection. Instructions for the use of each form appear on the reverse side of the form.

b. Circled items in figures 4 and 5 are partially or totally applicable to Slotted Line, NARDA Model 230. References in the ITEM column refer to paragraphs in the text which contain required detailed or additional maintenance information.

27. Performing Preventive Maintenance

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

a. Check for completeness and general condition of the slotted line. The components of the slotted line are listed in paragraph 6.

b. Check for suitability of location and for proper installation of equipment for normal operation.

c. Inspect the controls for binding, scraping, excessive looseness, and for positive action.

d. Check the slotted line for normal operation (par. 16).

e. Clean and tighten the exterior of the components, shock mounts, interior surfaces, and cable connectors.

f. Inspect the exposed metal surfaces of the transit case and the slotted line for rust and corrosion.

g. Inspect the shock mounts for cuts, breaks, and deterioration.

h. Inspect for looseness of accessible items, such as tuning and drive knobs.

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR											
INSTRUCTIONS: <i>See other side</i>											
EQUIPMENT NOMENCLATURE						EQUIPMENT SERIAL NO.					
LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; ① Defect corrected. NOTE: Strike out items not applicable.											
DAILY											
NO.	ITEM	CONDITION									
		S	M	T	W	T	F	S			
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories). PAR. 27 a										
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 27 b										
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS.										
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.										
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 27 c										
6	CHECK FOR NORMAL OPERATION. PAR. 27 d										
WEEKLY											
NO.	ITEM	1 C O N D I T I O N	2 C O N D I T I O N	3 C O N D I T I O N	4 C O N D I T I O N	5 C O N D I T I O N	6 C O N D I T I O N	7 C O N D I T I O N			
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 27 e										
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 27 f										
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 27 g										
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.										
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.										
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWER-STATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 27 h										
13	INSPECT STORAGE BATTERIES FOR DMRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.										
14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.										
15	INSPECT METERS FOR DAMAGED GLASS AND CASES.										
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING.										
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.										
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.										
19	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.										

DA FORM 11-238

REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

Figure 4. DA Form 11-238.

TM 5109-4

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT			
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR			
INSTRUCTIONS: See other side			
EQUIPMENT NOMECLATURE		EQUIPMENT SERIAL NO.	
LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; ⊕ Defect corrected. NOTE: Strike out items not applicable.			
NO	ITEM	NO.	ITEM
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (receiver, transmitter, carrying case, wire and cable, microphones, tubes, spare parts, technical manuals and accessories). PAR. 27a	19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTIONS, CRACKED SOCKETS; INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES.
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 27b	20	INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS.	21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION.
4	INSPECT SEATING OF READILY ACCESSIBLE "PUSH-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.	22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 27c	23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.
6	CHECK FOR NORMAL OPERATION. PAR. 27d	24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE.
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 27e	25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS.
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 27f	26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE.
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 27g	27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS.
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.	28	CHECK SETTINGS OF ADJUSTABLE RELAYS.
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDOW, TEARS, AND FRAYING.	29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSING, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 27h	30	INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.
13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS.
14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.	32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE.
15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 27i	33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.	34	INSPECT CATHODE RAY TUBES FOR BURNED SCREEN SPOTS.
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	36	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.
19	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.	37	MOISTURE AND FUNGIPROOF.

DA FORM 11-239

REPLACES DA AGO FORM 439, 1 DEC 50, WHICH IS OBSOLETE.

16-44303-1

TM 5109-5

Figure 5. DA Form 11-239.

Section III. LUBRICATION AND WEATHERPROOFING

28. Lubrication

Lubrication is not required for the satisfactory operation of this equipment. Refer to parent manuals for lubrication instructions for auxiliary equipment.

29. Weatherproofing Procedures and Precautions

a. General. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, and TB SIG 72, Tropical Maintenance of Ground Signal Equipment.

c. Arctic Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66, Winter Maintenance of Signal Equipment, and TB SIG 219, Operation of Signal Equipment at Low Temperatures.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75, Desert Maintenance of Ground Signal Equipment.

30. Rustproofing and Painting

a. When the finish on the case has been badly scarred or damaged, rust and corrosion can be prevented by touching up bared surfaces. Use #00 or #000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish.

Caution: Do not use steel wool. Minute particles frequently enter the case and cause internal shorting.

b. When a touch-up job is necessary, apply paint with a small brush. Remove rust from the case by cleaning corroded metal with solvent (SD). In severe cases, it may be necessary to use solvent (SD) to soften the rust and to use sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section IV. TROUBLE SHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

31. Scope

a. The trouble shooting and repair work that can be performed at the organizational maintenance level (operators and repairmen) is necessarily

limited in scope by the tools, test equipment, and replaceable parts issued, and by the existing tactical situation. Accordingly, trouble shooting is based on the performance of the equipment and the use of the senses in determining such troubles as burned-out crystals, broken cords, damaged contacts, etc.

b. The paragraphs which follow in this section help in determining which of the parts is at fault and in localizing the fault.

32. Visual Inspection

a. Failure of this equipment to operate properly usually will be caused by one or more of the following faults:

- (1) Worn, broken, or disconnected cords or plugs.
- (2) Burned-out crystals.
- (3) Auxiliary equipment inoperative.

b. When failure is encountered and the cause is not immediately apparent, check as many of these items as is practicable before starting a detailed examination of the component parts of the system. If possible, obtain information from the operator of the equipment regarding performance at the time the trouble occurred.

33. Trouble Shooting by Using Equipment Performance Check List

a. *General.* The equipment performance check list (par. 34) will help the operator to locate trouble in the equipment. The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures the operator can take. *To use this list, follow the items in numerical sequence.*

b. *Action or Condition.* For some items, the information given in the *Action or condition* column consists of various control settings under which the item is to be checked. For other items it represents an action that must be taken to check the normal indication given in the *Normal indications* column.

c. *Normal Indications.* The normal indications listed include the visible signs that the operator should perceive when he checks the items. If the indications are not normal, the operator should apply the recommended corrective measures.

d. *Corrective Measures.* The corrective measures listed are those the operator can make without turning in the equipment for repairs. A reference in the table to chapter 5 indicates that the trouble cannot be corrected during operation and that trouble shooting by an experienced repairman is necessary. If the slotted line is completely inoperative or if the recommended corrective measures do not yield results, trouble shooting is necessary.

34. Equipment Performance Check List

	Item No.	Item	Action or condition	Normal indications	Corrective measures
P R E P A R A T O R Y	1	Input signal.	Apply signal source, frequency 500 to 4,000 mc; modulation frequency corresponds to frequency of vswr amplifier, if tuned. Signal strength approximately 1 mw.		
	2	V _{swr} amplifier.	ON. Maximum gain.		
	3	Bolometer or crystal.	Inserted into detector on slotted line.		
S T A R T	4	Probe depth.	Maximum clockwise rotation.		
	5	V _{swr} amplifier.	Set for CRYSTAL or BOLOMETER and if bolometer is used, for 8.75 ma bias.		
	6	Tuning knob	Tune for maximum meter reading on vswr amplifier.	Meter reads.	Replace defective crystal or bolometer. No signal. No modulation. If vswr amplifier is tuned, modulation must be at same frequency (usually 1,000 cps).

34. Equipment Performance Check List (cont.)

	Item No.	Item	Action or condition	Normal indications	Corrective measures
S T A R T					Check cable and connectors. Amplifier inoperative.
E Q U I P M E N T P E R F O R M A N C E	7	Standard termination.	Connect standard termination to output of slotted line.		
	8	Drive knob.	Move carriage to <i>maximum</i> . Set amplifier for full-scale reading. Move carriage to <i>minimum</i> . Read v_{swr} .	V_{swr} agrees with known value of standard termination within .04.	Check output connector. Replace if damaged.
S T O P	9	CRYSTAL-BOLOMETER switch on the amplifier.	Turn to CRYSTAL. Disconnect all cables and auxiliary equipment.		

CHAPTER 4

THEORY

35 General

Slotted Line, NARDA Model 230 is essentially a length of coaxial line that enables the operator to get a measurement of v_{swr} by sampling the voltage distribution along its length. This usually is done in wave guides and coaxial lines by putting a slot in the outside wall, inserting a probe in the slot, and moving the probe along the length of the transmission line. This method in its simplest form, however, is undesirable because it results in excessive radiation from the slot and in measurement errors from the most minute variations in probe depth.

36. Parallel Plane Transmission Line

The Slotted Line, NARDA Model 230 overcomes these undesirable factors by using a particular coaxial configuration that does not radiate and is insensitive to slight variations in probe depth. This configuration consists of two parallel planes, approximately $\frac{7}{8}$ inch apart, and a circular center conductor. The dimensions are chosen to give a characteristic impedance of 50 ohms. The input and output sections are conventional coaxial lines with a modified Radio Frequency Plug UG-21B/U at one end and a modified Radio Frequency Jack UG-23B/U at the other end. The transitions from the end lines to the central section are accomplished by undercutting the center conductor to provide a low residual v_{swr} .

37. Probe and Carriage

The moving carriage carries the probe that samples the voltage distribution in the main line. The tuning knob adjusts the length of a stub line inside the probe carriage to provide maximum transfer of power to the detector. The probe output is coupled directly to the bolometer or crystal in the radio frequency detector which also contains a built-in filter circuit. The rectified output is a voltage that is amplified by the v_{swr} amplifier and is indicated on the meter of the amplifier.

38. Use of Bolometer and Crystal

One crystal (1N23B) and two bolometers are supplied with the slotted line. The crystal is a simple rectifier of the silicon-diode type. It operates as

a conventional rectifier in conjunction with the built-in filter circuit. The bolometer is basically a thermally sensitive resistor. It consists of a short length of very fine platinum wire known as a Wollaston wire. When the output of the slotted line is connected to a vswr amplifier, a bias current flows through the bolometer and causes its resistance to increase. The radio frequency power coupled to the bolometer by the probe causes the resistance of the bolometer to fluctuate at the modulation frequency. Because of the bias current (dc), this fluctuation results in an alternating voltage across the bolometer at the modulation frequency. This voltage is fed into the vswr amplifier. Since the amplitude of the voltage is directly proportional to the amplitude of rf power, the bolometer is a true square-law detector. For crystals, the direct proportion of output voltage to probe power is true only over a narrow range, at low power levels, and in the absence of sharp pulses. For accurate measurements over a wide range (vswr greater than 3:1) and for pulsed modulation, always use a bolometer detector. Most military and commercial vswr amplifiers are designed to supply approximately 8.75 ma bias to a 200-ohm bolometer. This is the correct bias for the bolometers supplied with the slotted line.

CHAPTER 5

FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

Section I. TROUBLE SHOOTING AT FIELD MAINTENANCE LEVEL

39. Trouble-shooting Procedures

The first step in servicing a defective slotted line is to localize the fault. This is to be done primarily by eliminating one by one the most likely sources of trouble. First, be sure that all the auxiliary equipment is operating correctly and that the fault is actually in the slotted line. Next, substitute a good crystal or bolometer in the detector to determine whether the trouble is a faulty crystal or bolometer. Finally, check proper mating of the input and output type N connectors and the detector output BNC connector. With a crystal or bolometer in the detector, check the resistance from the BNC center contact to ground. *Be sure to use the $R \times 10$ or $R \times 100$ scale only on the ohmmeter.* With a bolometer in place, the resistance should be approximately 200 ohms. With a crystal, the resistance will depend on the polarity of the ohmmeter leads. By reversing the leads, two readings should be obtained: approximately 400 ohms and over 10,000 ohms. With the crystal or bolometer removed, the ohmmeter should indicate an open circuit (more than 10 megohms). If the correct readings are not obtained, replace the detector assembly. If the above steps fail to locate the fault, there is a damaged part in the probe carriage housing. Disassemble the carriage housing as shown in figure 7 by following the instructions in paragraph 43*b*. Examine each part visually for damage, broken or bent fingers, loose set screws, or poor contact, replace or repair the faulty part.

40. Test Equipment Required for Trouble Shooting

Locating and repairing faults in the slotted line require the tools listed in paragraph 23, plus Multimeter TS-352/U (TM 11-5527), and a retainer ring tool (Ordnance No. 41-P-1992-36).

41. General Precautions

Observe the following precautions when servicing the slotted line:

- a. Never use the R x 1 scale of the ohmmeter or the crystal or bolometer will be damaged. Start with the highest RX range and switch to lower ranges as required to obtain the desired reading.
- b. Handle all spring finger parts with care to avoid bending or breaking the spring fingers.
- c. Do not disassemble or adjust the shafts of the ball bearings on which the carriage rides unless one of the bearings is obviously damaged.

42. Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the slotted line. It lists the symptoms that the repairman may observe and indicates the probable source of trouble and the appropriate corrective measures.

42. Trouble-shooting Chart (cont.)

Symptom	Probable trouble	Correction
1. Auxiliary equipment operating; no reading can be obtained on vswr amplifier.	1. Open crystal or bolometer. Broken cable connection to vswr amplifier. Vswr amplifier inoperative. Detector assembly shorted or open. Defective part inside carriage assembly.	1. Replace crystal or bolometer. Replace cable. Replace vswr amplifier. Replace detector assembly. Disassemble probe carriage, and repair or replace damaged part.
2. Vswr measurement of standard termination is too high.	2. Probe screwed in too far. Damaged output connector (type N).	2. Turn probe depth knob counterclockwise to obtain minimum usable signal. Replace connector.
3. Erratic tuning.	3. Bent or broken spring fingers inside probe housing.	3. Disassemble probe housing and inspect all contact fingers. Repair or replace damaged part.
4. Vswr measurement varies over length of carriage.	4. Damaged ball bearing on carriage.	4. Replace ball bearing and adjust shafts to make probe travel parallel to parallel plates.

Section II. REPAIRS

43. Replacement of Parts

Note. Observe the general precautions given in paragraph 41.

a. General. Replacement of parts is accomplished by disassembling the slotted line to make a part accessible, and then reassembling the equipment. Except for the general precautions given in paragraph 41, no special instructions are needed for the disassembly and reassembly of the slotted line.

b. Disassembly. Refer to figures 6 and 7, which indicate the assembly relationship of all replaceable parts. First remove the scale (held in place by two machine screws). Next remove the entire probe and carriage assembly by springing back the hinged ball bearing bracket (3, fig. 6) and lifting the carriage away from the slotted line. Set the carriage aside and proceed to disassemble the slotted line. Remove the parts in the identical sequence indicated by the reference numbers in figure 6. To disassemble the probe carriage, refer to figure 7 and remove parts in a sequence identical to the reference numbers in the figure. Use the retainer ring tool to remove the retainer ring (11, fig. 7).

c. Assembly. Reassemble the probe carriage first. Refer to figure 7 and assemble parts in *reverse* numerical sequence. Then refer to figure 6 and reassemble the remaining parts in *reverse* numerical sequence. Finally replace the carriage assembly and the scale.

44. Refinishing

Instructions for refinishing badly marred exterior cabinets are given in TM 9-2851, Painting Instructions For Field Use. Refer to these instructions as necessary.

Section III. FINAL TESTING

45. General

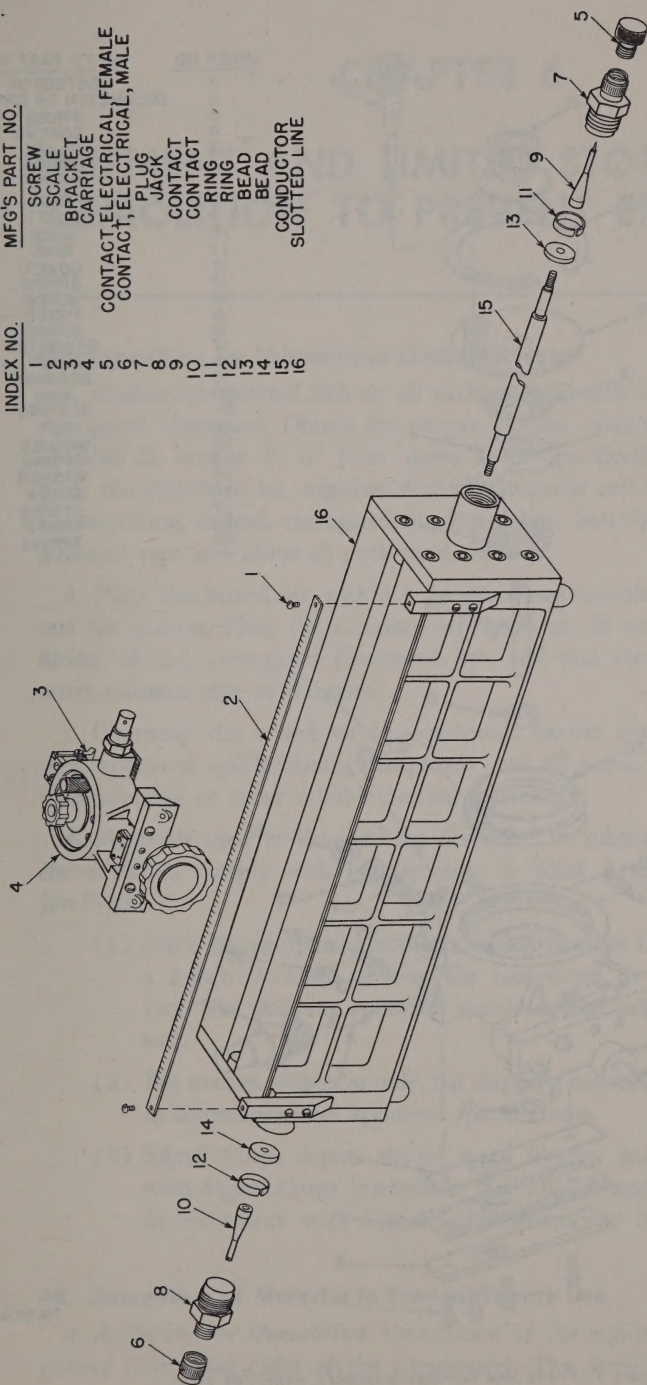
This section is intended as a guide to be used in determining the quality of performance of a repaired Slotted Line, NARDA Model 230. The tests may be performed by maintenance personnel with adequate test equipment and the necessary skills. Repaired equipment meeting these requirements will furnish uniformly satisfactory operation.

46. Procedure

The slotted line is operating satisfactorily if it makes an accurate measurement of *vswr*. Therefore, follow the procedures outlined in paragraphs 15 and 16 to measure the *vswr* of an equipment whose *vswr* is known. The measurement taken at any portion of the carriage travel should agree with the known value within .04.

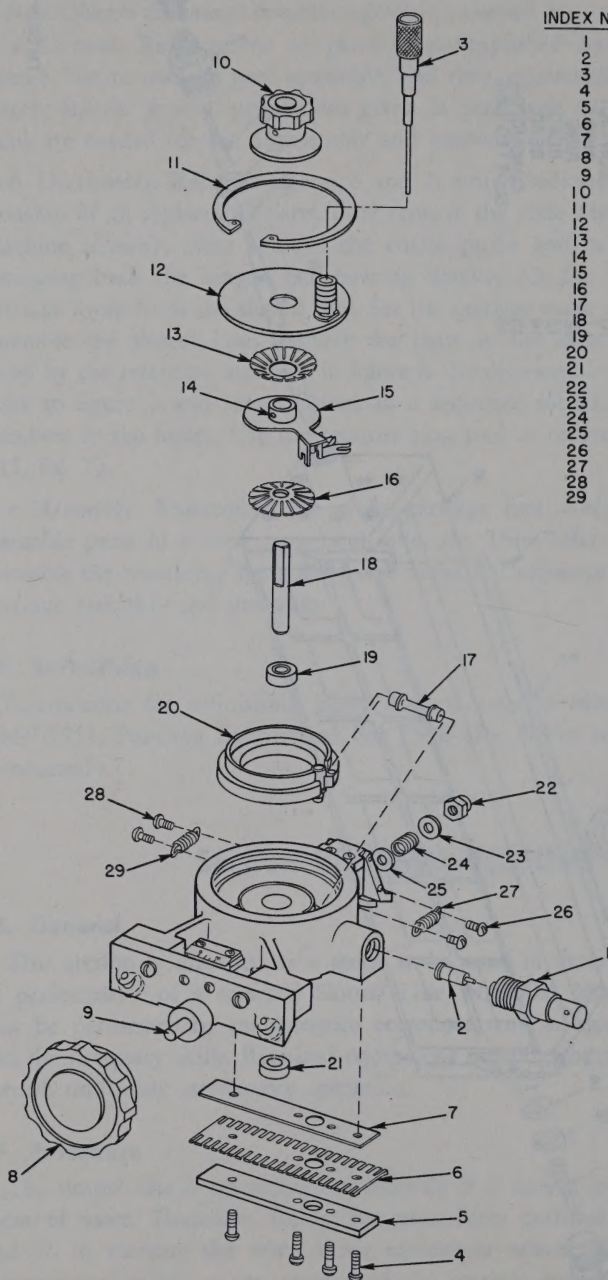
INDEX NO. MFG'S PART NO.

- | | |
|----|-----------------------------|
| 1 | SCREW |
| 2 | SCALE |
| 3 | BRACKET |
| 4 | CARRIAGE |
| 5 | CONTACT, ELECTRICAL, FEMALE |
| 6 | CONTACT, ELECTRICAL, MALE |
| 7 | PLUG |
| 8 | JACK |
| 9 | CONTACT |
| 10 | CONTACT |
| 11 | RING |
| 12 | RING |
| 13 | BEAD |
| 14 | BEAD |
| 15 | CONDUCTOR |
| 16 | SLOTTED LINE |



TM 5109-6

Figure 6. Slotted Line, NARDA Model 230, exploded view.



INDEX NO.	MFG'S PART NO.
1	DETECTOR
2	BOLOMETER OR CRYSTAL
3	PROBE
4	SCREWS
5	PLATE
6	SPRING
7	PLATE
8	KNOB
9	SHAFT
10	KNOB
11	RING
12	COVER
13	SPRING
14	SCREW
15	TUNER
16	SPRING
17	RESISTOR
18	SHAFT
19	BEARING
20	RING
21	BEARING
22	NUT
23	WASHER
24	SPRING
25	WASHER
26	SCREW
27	SPRING
28	SCREW
29	SPRING

Figure 7. Probe and carriage assembly, exploded view.

TM 5109-7

CHAPTER 6

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

47. Repacking for Shipment or Limited Storage

a. Cushion the slotted line on all surfaces with cells or pads fabricated of corrugated fiberboard. Obtain the proper amount of desiccant, as prescribed in table II, section E, of Joint Army-Navy Specification JAN-P-116, and place the cushioned set, together with the manuals and the desiccant, within a close-fitting, slotted, corrugated fiberboard box. Seal the entire closure with gummed tape and blunt all corners of the box.

b. Place the boxed set within a moisture-vaporproofed barrier, and heat-seal the closure. Place the moisture-vaporproofed set within a second close-fitting, slotted, corrugated fiberboard box and seal the entire closure with water-resistant tape or adhesive.

c. Overwrap the boxed set in waterproof barrier material. In accordance with approved specifications, completely seal all joints, seams, and closures with adhesive or other suitable sealing material.

d. Materials used in the packing described in subparagraphs *a*, *b*, and *c* above should comply with requirements in Joint Army-Navy Specification Jan-P-100.

- (1) Place the equipment within a nailed wooden box lined inside with a 2-inch thickness of excelsior compacted to 3 pounds per cubic foot. The shipping container should *not* be lined with a waterproof bag.
- (2) For oversea shipment only, the shipping container should be strapped in accordance with approved specifications.
- (3) Signal Corps depots should mark interior packages in accordance with Signal Corps Instruction No. 726-15, and shipping containers in accordance with Signal Corps Instruction No. 720-14.

48. Demolition of Materiel to Prevent Enemy Use

a. Authority for Demolition. Demolition of the equipment will be accomplished only upon order of the commander. The demolition procedures out-

lined below will be used to prevent the enemy from using or salvaging this equipment.

b. Methods of Destruction.

- (1) *Smash.* Smash the controls, case, carriage, connectors, and internal parts; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.
- (2) *Cut.* Cut the output cable; use axes, handaxes, or machetes.
- (3) *Burn.* Burn cords and manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.
- (4) *Bend.* Bend center conductor.
- (5) *Explosives.* If explosives are necessary, use firearms, grenades, or TNT.
- (6) *Disposal.* Bury or scatter the destroyed parts in slit trenches, fox holes, or throw them into streams.
- (7) *Destroy.* Destroy everything.

